

(12) UK Patent Application (19) GB (11) 2 202 170 (13) A

(43) Application published 21 Sep 1988

(21) Application No 8802404  
 (22) Date of filing 3 Feb 1988  
 (30) Priority data  
 (31) 62/026285 (32) 9 Feb 1987 (33) JP

(51) INT CL<sup>4</sup>  
 H02K 15/085 3/12

(52) Domestic classification (Edition J):  
 B3A 188  
 H2A DA  
 U1S 1820 B3A H2A

(71) Applicant  
 Hitachi Ltd  
 (Incorporated in Japan)  
 6 Kanda Surugadai 4-chome, Chiyoda-ku, Tokyo,  
 Japan  
 (72) Inventors  
 Yasutaka Kuribashi  
 Kenji Yaginuma  
 Tadayuki Suenobu  
 (74) Agent and/or Address for Service  
 Langner Parry  
 52/54 High Holborn, London, WC1V 6RR

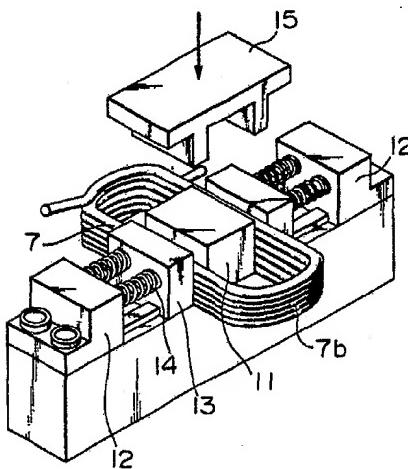
(56) Documents cited  
 GB 1079815 EP A 0114260

(58) Field of search  
 B3A  
 H2A  
 Selected US specifications from IPC sub-class  
 H02K

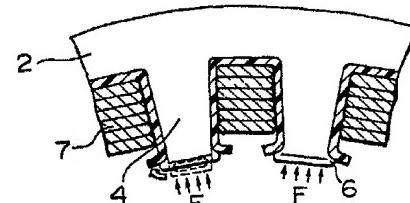
(54) Alternator stator with inserted windings

(57) The stator includes a core 2 having a plurality of slots formed in its inner periphery; a stator winding 7 partially inserted in each of said slots of said stator core; and an electrically insulating material inserted between said stator winding and the surface of said stator core opposing said stator winding, wherein said slots formed in said stator core have a substantially rectangular cross-sectional form and the portions of said stator winding to be inserted into said slots also have a substantially rectangular cross-sectional form, with the other portions 7b having a circular cross-sectional form. The rectangular cross-section of the winding portions is achieved before insertion in the slots by a hydraulic presser plate 15. The winding conductor initially may be of hollow cross-section.

F I G. 4



F I G. 7B



GB 2 202 170 A

1/5

2202170

FIG. 1

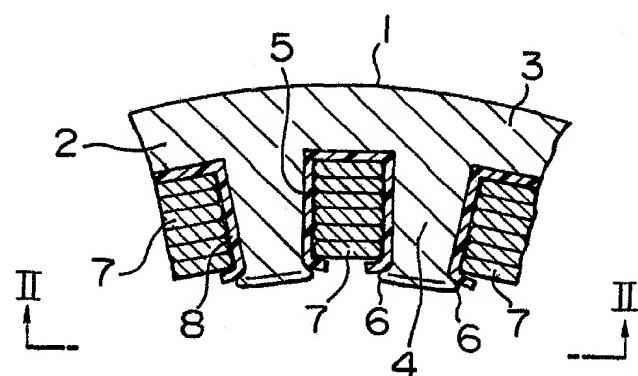
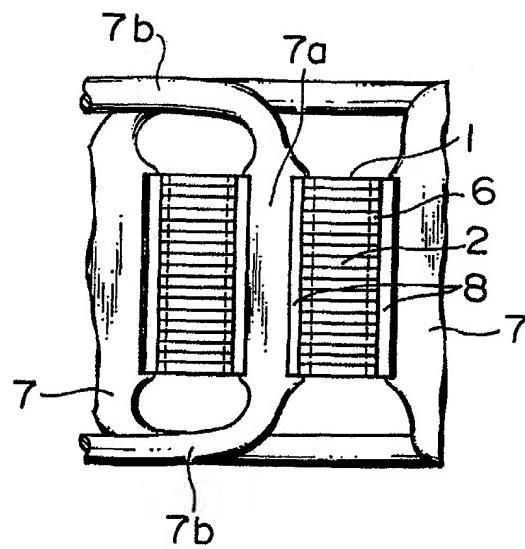


FIG. 2



2/5

2202170

FIG. 3

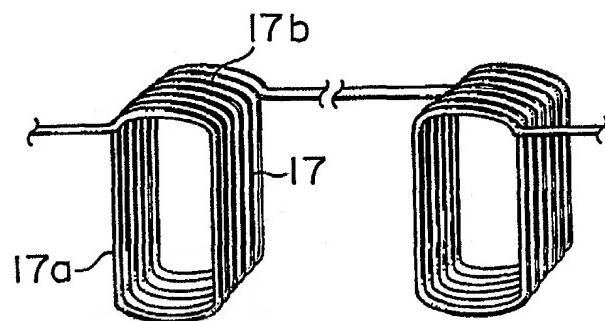
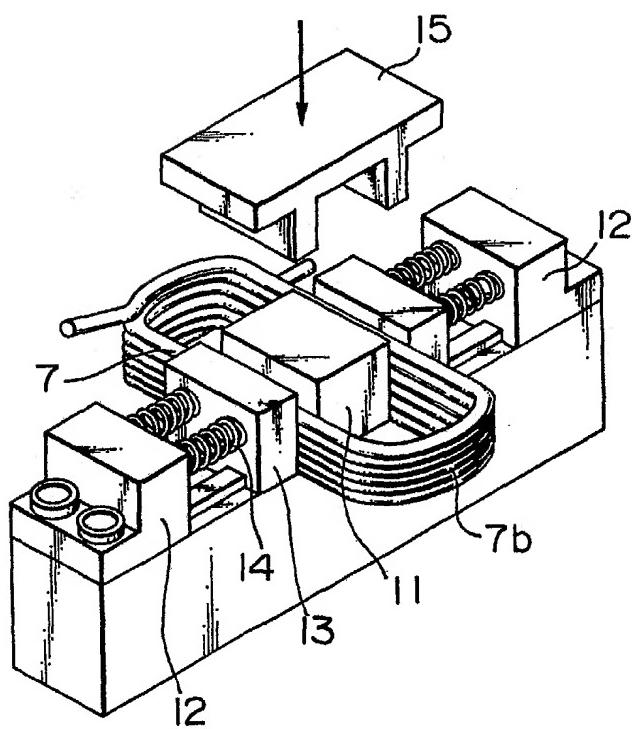


FIG. 4



2202170

3/5

FIG. 5

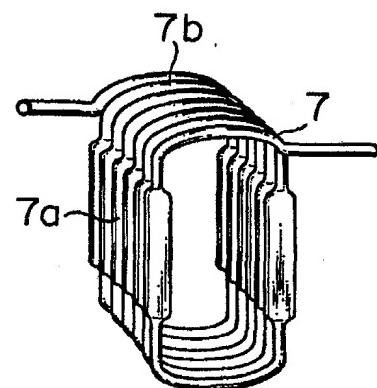
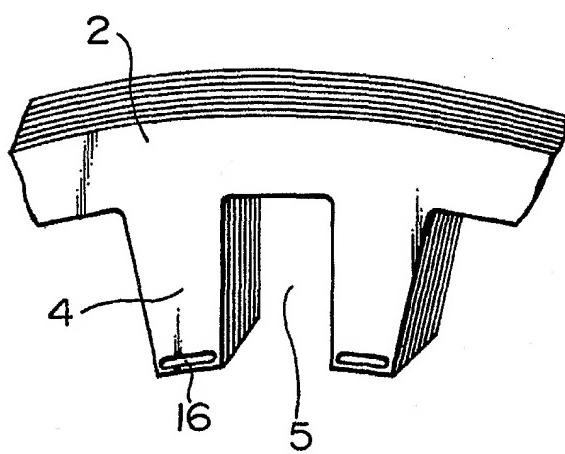


FIG. 6



2202170

4/5

FIG. 7A

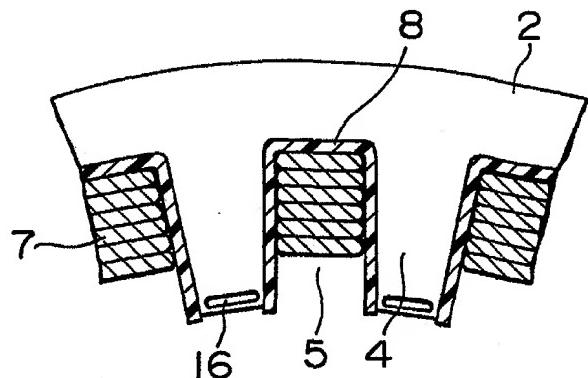


FIG. 7B

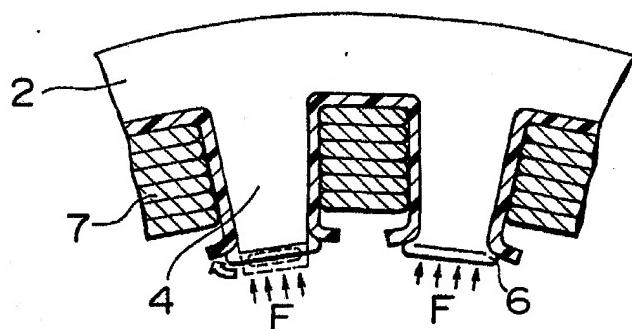


FIG. 8A

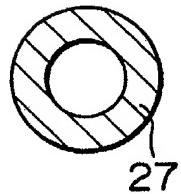
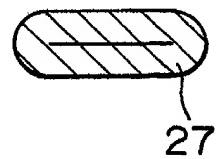


FIG. 8B



2202170

5/5

FIG. 9

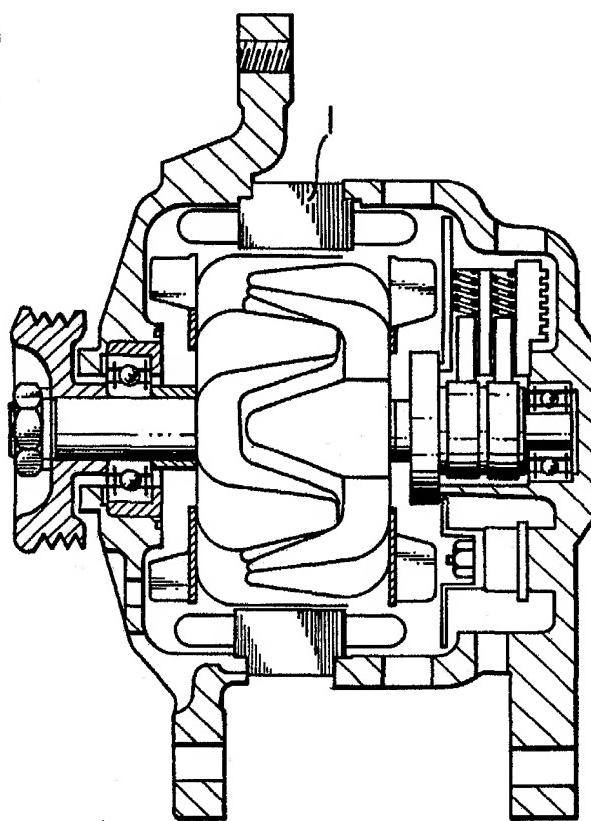
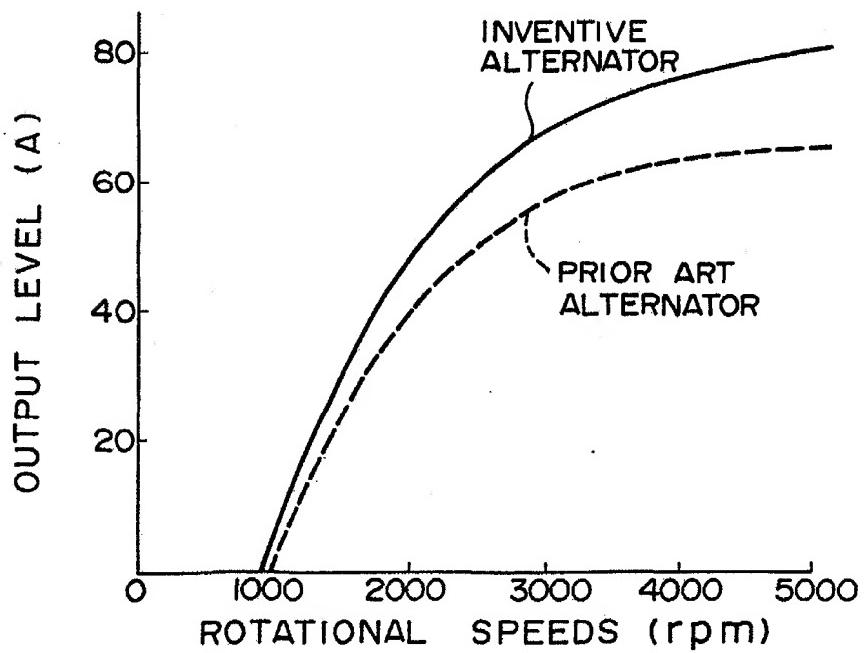


FIG. 10



2202170

- 1 -

**STATOR FOR USE IN ALTERNATOR FOR VEHICLE**  
**AND METHOD OF PRODUCING THE SAME**

**1 BACKGROUND OF THE INVENTION**

**1. Field of the Invention**

The present invention relates generally to alternators and, in particular, to a stator which is suitable for use in an alternator for a vehicle or the like and which is capable of being reducted in size and of providing an increase in output, as well as to a method of producing the same.

**2. Description of the Related Art**

10 In such a stator for use in an alternator for a vehicle, a solid electric wire having a circular cross section as disclosed, for example, in Japanese Patent Laid-open No. 55-79660 is fitted into slots formed in the stator while retaining its cross-sectional form, 15 extensions formed along circumferentially opposing edges of the end of each toothed portion of a stator core are folded to form partially closed apertures for the slots.

As disclosed in Japanese Patent Laid-open No. 55-94567, a similar solid electric wire having a 20 circular cross section is fitted into slots formed in the stator and in turn the wire or winding is pressed in the direction of the depth of the slots in order to improve the ratio of the area occupied by the winding to that of the slot (hereinafter referred to as "space 25 factor"). Finally, opposing edges of the ends of the

- 2 -

1 toothed portions of the stator core are circumferential-  
ly extended to form partially closed apertures for the  
slots.

In the above-described related arts, however,  
5 since the solid electric wire or winding having a  
circular cross section is fitted into the slots without  
having its cross-sectional form changed, the above space  
factor cannot be improved owing to the fact that spaces  
are necessarily formed between successive turns of the  
10 winding. This makes it difficult to improve the level  
of output of the alternator. In the type in which  
pressure is applied to the solid electric wire or wind-  
ing of circular cross section which has been fitted  
into the slots, the turns of the winding within the  
15 slots may partially cross each other, so that it might  
become impossible to maintain the proper arrangement of  
the turns of the winding. As a result, while the  
winding is being pressed, the electrically insulating  
film coated over the surface of the winding may be  
20 damaged and, hence, the windings might be short-  
circuited. Accordingly, adoption of such a method  
results in an increased proportion of defects occurring  
during a mass-production process and, hence, a lowering  
in productivity.

25 It is widely known that large electric rotary  
machines in particular employ a flat rectangular wire  
in place of a round wire. However, if such flat  
rectangular wire is used, as it is, in small alternators

- 3 -

1 or the like to which the present invention pertains,  
the following disadvantages will result. In general,  
before being fitted into the slots, the winding needs  
to be formed into a predetermined shape. However, in a  
5 mass-production process for producing a large volume of  
windings in a short period of time by means of winding  
machines, use of this type of flat rectangular wire  
is not suitable, since such wire is inferior in  
workability as compared with the round wire because of  
10 the presence of curvature or twisting at its end coil  
portions.

#### SUMMARY OF THE INVENTION

It is therefore an object of the present  
invention to provide a structure for a stator suitable  
15 for use in an alternator for a vehicle and a method of  
producing such a stator in which the space factor of a  
winding is greatly improved to increase the level of  
output of the alternator; in which the winding coating  
is in no way damaged during assembly; and which is  
20 superior in productivity.

The above object is achieved by providing a  
stator suitable for use in an alternator for a vehicle  
comprising a stator core having a plurality of slots  
formed in its inner periphery; a stator winding partial-  
25 ly inserted in each of the slots of the stator core;  
and an electrically insulating material inserted between  
the stator winding and the surface of the stator core.

- 4 -

- 1 opposing the stator winding, wherein the slots formed  
in the stator core have a substantially rectangular form  
in cross section and the portions of the stator winding  
to be inserted into the slots also have a substantially  
5 rectangular form in cross section, with the other por-  
tion having a circular cross-sectional form.

In accordance with the present invention, part  
of the winding fitted into the slots of the stator is  
so formed that the portions of the winding inserted  
10 into the slots are provided with a substantially rectan-  
gular cross-sectional shape by the application of  
pressure, whereby the space factor of the winding  
within the slots is greatly improved. In addition,  
since the winding is made from winding material having  
15 at least a circular cross-sectional form, it is possible  
to eliminate various disadvantages which might have  
heretofore been involved in winding formation.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross section of a portion of a  
20 stator for use in an alternator for a vehicle in accord-  
ance with the present invention;

Fig. 2 is a view taken in the direction  
indicated by an arrow II of Fig. 1;

Figs. 3 through 5 are diagrammatic views  
25 illustrating the formation of stator winding for the  
stator incorporated in an alternator for a vehicle in  
accordance with the present invention;

( - 5 -

1 Fig. 3 illustrates the wound state of winding  
material to which the invention pertains;

Fig. 4 is a diagrammatic perspective view  
illustrating the process of pressing the winding  
5 material shown in Fig. 3 by means of a pressure former;

Fig. 5 is a diagrammatic perspective view  
illustrating a stator winding which is formed in accordance  
with the present invention;

Fig. 6 is a diagrammatic perspective view of  
10 a stator core of an alternator for a vehicle in accordance  
with the present invention, and illustrates a state  
wherein extensions serving as magnetic flux collecting  
portions have not yet been formed;

Figs. 7A and 7B are schematic views illustrating  
15 a method of producing the magnetic flux collecting  
portions of the stator for an alternator for a vehicle  
in accordance with the present invention, with Fig. 7A  
showing a state wherein a stator winding is fitted into  
the slots of the stator while Fig. 7B showing a state  
20 wherein the end surface of each toothed portion of the  
stator core is formed under pressure;

Figs. 8A and 8B are cross sections of another  
example of the stator winding of the stator of an  
alternator for a vehicle in accordance with the present  
25 invention, with Fig. 8A being a cross section of a  
hollow conductor wire while Fig. 8B shows the hollow  
conductor wire which is formed under pressure in a  
substantially rectangular cross section.

- 6 -

1           Fig. 9 is a diagrammatic cross section of an  
alternator for a vehicle which incorporates the stator  
of the invention;

5           Fig. 10 is a characteristic chart illustrating  
a comparison between the output characteristic of the  
alternator for a vehicle which incorporates a stator of  
the invention and the output characteristic of a con-  
ventional type of vehicle alternators.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

10           A stator suitable for use in an alternator  
for a vehicle in accordance with the present invention  
and a method of producing the same will be described  
below in conjunction with an illustrated preferred  
embodiment. In the drawings, like reference numerals  
15 are used to identify like or corresponding elements.

Fig. 1 illustrates in cross section a portion  
of the armature of an alternator for a vehicle, that  
is, a stator 1. The stator 1 has a stator core 2  
composed of laminated steel plates each having a pre-  
20 determined stamped form. The stator core 2 has a  
cylindrical portion 3 and a plurality of toothed por-  
tions 4 each of which projects radially inward of the  
cylindrical portion 3, and each slot 5 is defined  
between adjacent toothed portions 4. The slot 5 has  
25 a rectangular cross section. In the present embodi-  
ment, the stator 1 which is suitable for use in an  
alternator for a vehicle has twelve slots formed in

- 7 -

1 the cylindrical portion 3 of the stator core 2 on the  
side of its inner periphery. In Fig. 1, only three of  
these slots are shown, by way of example. A pair of  
extensions 6, which are elongated circumferentially in  
5 opposite directions, are formed on the circumferentially  
opposing edges of the inner end of each of the toothed  
portions 4. Each of the extensions 6 serves to collect  
magnetic flux and to define the partially closed  
aperture of the slot 5 for the purpose of preventing  
10 projection of a winding which will be described in  
detail later.

In the present embodiment, a stator winding 7 composed of six turns is inserted in each of the slots 5 of the stator 1. As a matter of course, this stator  
15 winding is wound so that three-phase output may be provided in a similar manner to that of prior art vehicle alternators. An electrically insulating sheet 8, such as "Nomex", having a high degree of heat resistance is interposed between the stator core 2 and the  
20 stator winding 7. Thus electrical insulation is positively provided between the stator core 2 and the stator winding 7.

Fig. 2 is a plan view of the alternator stator 1 shown in Fig. 1, taken in the direction indicated by  
25 an arrow II of Fig. 2. As clearly shown in Fig. 2, the stator winding 7 accommodated in the slot 5 of the stator core 2 has a portion 7a and coil end portions 7b. The portion 7a is inserted in the slot 5 and has a flat or

- 8 -

1 rectangular cross section. The remaining portions or  
coil end portions 7b have a circular cross-sectional  
form. As can be seen from the foregoing, since each  
of the slots 5 having a substantially rectangular form  
5 in cross section receives the winding which has a  
similarly rectangular form in cross section, the space  
factor of the winding within the stator slot 5 is  
improved.

A method of producing the above-described  
10 stator winding 7 will now be described.

As shown in Fig. 3, a solid electric-wire  
material 17 having a circular cross section is wound  
several times, e.g., six times, into a substantially  
rectangular form, thereby preparing a winding having a  
15 predetermined form. In the illustrated example, the  
winding material 17 is wound into a substantially  
rectangular form and coil end portions 17b are shaped  
in an arc. Therefore, when the winding is inserted into  
the slot 5 of the stator core 2, the coil end portion  
20 17b is adapted to be easily worked. Also, since  
electric-wire material having a circular cross sectional  
form is used, no deterioration in workability occurs  
due to twisting of the electric wire in contrast to the  
case in which the aforesaid winding is formed from a  
25 so-called rectangular wire. It is therefore unnecessary  
to take account of twisting of electric wires. Accord-  
ingly, it is evident that the present winding material  
is suitable for use in a mass-production process because

- 9 -

1 of the superior workability.

After the stator winding material 17 has been shaped into a predetermined form in the above-described manner, its portion 17a thereof which is to be inserted 5 into the slot 5 is shaped in a flat form by a pressure former 9. The pressure former 9 has a base 10, a stopper 11 provided on the mid portion half way along the base 10 in the lengthwise direction, a pair of blocks 12 provided at the longitudinal opposite ends 10 of the base 10, a pair of sliders 13 longitudinally slidable over the base 10, springs 14 each secured at one end to the block 12 and at the other to the slider 13, and a pusher 15 moved vertically by means of hydraulic pressure or the like. The winding material 15 which has been formed as shown in Fig. 3 is inserted between the stopper 11 and the sliders 13, and the portions 17a thereof which are to be inserted into the slots, that is, the portions other than the coil end portions 17b are retained therebetween by the force of 20 the springs 12. Thereafter, the inserted portions 17a are pressed by the pusher 15 in the direction indicated by an arrow shown in Fig. 4. As the result of this application of pressure, the stator winding material 17 is formed into a stator winding 7 such as that shown 25 in Fig. 5 in which the portion other than the coil end portions 7b, that is, the portions 7a to be inserted into the slot 5, has a substantially square, e.g., rectangular form in cross section. In the above-

- 10 -

1 described embodiment, after the winding material has  
been wound and the thus-obtained winding have been  
placed in such a manner that its turns are superimposed,  
predetermined portions of the superimposed turns are  
5 pressed. However, after the predetermined portions  
alone of the winding material have been pressed, the  
obtained winding material may be wound into a desired  
form.

The stator winding 7, which has been formed  
10 in the above-described manner, is securely inserted  
into each of the slots 5 defined between the adjacent  
toothed portions 4 of the stator core 2 shown in Fig.  
6, with an electrically insulating sheet interposed  
therebetween. As shown in Fig. 6, a substantially  
15 ellipsoidal through hole 16 is axially formed through  
each of the toothed portions 4 of the stator core 2.  
As will be described later, the previously-mentioned  
extensions 6 serving as magnetic-flux collecting  
portions are formed by pressing the end surface of each  
20 of the toothed portions 4. It is thus possible to  
prevent the inserted winding from coming out of the  
slots 5. As will be evident from the foregoing, after  
the winding 7 has been inserted into each of the slots  
5, the extension 6 serving as a magnetic-flux collecting  
25 portion is formed on the end surface of the toothed  
portion 4 of the stator core 2. Accordingly, even the  
winding 7 that is formed in a substantially rectangular  
shape can be easily inserted into each of the slots 5.

- 11 -

- 1 It will be appreciated that the efficiency of assembly  
is remarkably improved, particularly, in a mass-  
production process.

The following is a description of a method of  
5 forming the extensions that serve as magnetic-flux  
collecting portions of the stator core 2.

Referring to Fig. 7A, six turns of the stator  
winding 7 are inserted into each of the slots 5 with the  
electrically insulating sheet 8 interposed between the  
10 winding 7 and the surface of the slot 5.

Subsequently, as shown in Fig. 7B, the end  
surface of the toothed portion 4 of the stator core 2  
is pressed by means of a suitable pressing means (for  
example, a press or a roller) in the direction indicated  
15 by illustrated arrows F. As shown by solid lines in  
Fig. 7B, the through holes 16 axially formed through  
the end portions of the toothed portions 4 are crushed  
and at the same time the portions of the stator core 2  
adjacent to the circumferentially opposing sides of the  
20 through hole 16 are squeezed outwardly parallel to the  
circumference of the stator core 2. It is therefore  
possible to form the magnetic-flux collecting portions  
6 so that each has an ideal shape close to an arc.

In the above-described embodiment, by way of  
25 example, the solid electric-wire material having a  
circular cross-sectional form is used to form the stator  
winding. In the present invention, however, a hollow  
conductor wire 27 such as that shown in Fig. 8A may be

- 12 -

1 used in place of the circular wire material. As  
illustrated, the hollow conductor core 27 originally  
has an annular cross section. If the conductor core 27  
is pressed, it assumes an elongated form with rounded  
5 ends such as that shown in Fig. 8B. As is evident from  
the foregoing, if the hollow conductor 27 is employed  
in the pressing process explained previously in connec-  
tion with Fig. 4, the level of pressure required for  
pressing can be reduced as compared with the solid round  
10 wire, and it is possible to easily and positively shape  
the round wire into a rectangular cross-sectional form.  
As a matter of course, the portions of the hollow  
conductor 7 to be inserted into the slots are formed  
in a flat shape. In addition, the degree of pressure  
15 required for working the hollow conductor wire can be  
reduced as compared with that required when working a  
solid conductor wire. Accordingly, an electrically  
insulating film coated over the winding is less likely  
to be damaged during pressing, and the proportion of  
20 defects can be reduced to an extremely low level.

Fig. 9 shows in cross section an alternator  
for a vehicle which incorporates the above-described  
stator 1. Fig. 10 illustrates a comparison between the  
output characteristic of a typical prior art alternator  
25 and that of an alternator which incorporates the stator  
of the present invention. As can be seen from Fig. 10,  
with the arrangement of the present invention, it is  
possible to improve the ratio of the area occupied by

- 13 -

1 the winding to that of the slot, that is, the space  
factor to a level equivalent to about 80%. In conse-  
quence, as shown in the characteristic chart of Fig. 10,  
it is possible to enhance the level of output over the  
5 range of all rotational speeds of the alternator as  
compared with the output level of the prior art vehicle  
alternator having the same size (its output character-  
istic is shown by a dashed line). In particular, it  
was confirmed that the level of output at a rated  
10 rotational speed of 5000 rpm could be increased by about  
25% as shown by a solid line.

As is evident from the foregoing description,  
the present invention succeeds in providing a stator  
having a large space factor suitable for use in an  
15 alternator for a vehicle so that it is possible to  
achieve a vehicle alternator which is capable of being  
reduced in size and of providing an increase in output.

- 14 -

CLAIMS:

1. A stator suitable for use in an alternator for a vehicle comprising:

a stator core having a plurality of slots formed in an inner periphery thereof;

5 a stator winding having portions inserted in each of said slots of said stator core; and

an electrically insulating material inserted between said stator winding and said stator core;

wherein said slots formed in said stator 10 core have a substantially rectangular cross-sectional form, and said portions of said stator winding inserted into said slots also have a rectangular cross-sectional form and a remainder of said stator winding has a circular cross-sectional form.

15 2. A stator according to Claim 1, wherein said remainder of said stator winding has a hollow cross-sectional form.

3. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including 20 a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising 25 the steps of press-forming the portions of said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially

- 15 -

rectangular cross-sectional form.

4. A method according to Claim 3, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

5 5. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator 10 core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of winding a winding material having a circular cross-sectional form into a predetermined winding shape; and subsequently press-forming the 15 portions of said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially rectangular cross-sectional form.

6. A method according to Claim 5, wherein said stator winding is produced from a winding material 20 having a hollow cross-sectional form.

7. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having 25 portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of press-forming the portions of

- 16 -

said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially rectangular cross-sectional form; and subsequently winding said winding material into a predetermined winding form, thereby forming said stator winding.

8. A method according to Claim 7, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

9. A stator substantially as herein described with reference to and as shown in Figures 1 to 7B, 9 and 10 or 8A or 8B of the accompanying drawings.